OPERATIONAL TESTING OF ESTHETIC EVALUATION PROCEDURES

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Increasing emphasis is being placed on the prediction and evaluation of the impact of land-use decisions on natural resources, including natural beauty. The Resources Planning Act mandates the permanent, systematic assessment of renewable natural resources and the continuous review of federal land management policies (Bergoffen, 1976). The Multiple-Use Sustained-Yield Act recognizes amenity values, including natural beauty and recreation potential, as products of the National Forests, in addition to the more traditional products of wood, water, and forage. The economic tradeoffs involved in multiple-use planning have been aided by the development of more sophisticated management tools, including linear and goal programming and other optimization techniques (Schuler and Meadows, 1975; Field, 1973; Cox, Haught, and Zube, 1972).

These advances have led to an increasing need for information and quantification of amenity values (Wyckoff, 1971) and several procedures for measuring the scenic value of landscapes have been proposed (reviewed in Arthur, Daniel, and Boster, 1976). One such method is the Scenic Beauty Estimation (SBE) method developed by Daniel and Boster (1976). The SBE method provides evaluations of the esthetic quality of forest landscapes based on perceptual judgments of representatives of the general public. The participation of the public in this method is consistent with both a recent legal mandate, the 1976 Forest Management Act, and the theoretical assumption that esthetic judgments are dependent upon both the characteristics of

the evaluated object and the standards and preferences of the relevant perceivers of that object. The SBE method has been thoroughly tested for reliability, validity, and sensitivity, and has been found useful in a number of applications, including the assessment of effects of harvesting procedures on scenic quality (Wheeler, 1976); the description of post-harvest scenic recovery functions (Daniel and Anderson, 1977); and the development of predictive models of landscape quality for ponderosa pine forests of the type found in northern Arizona (Arthur, 1976), among others.

However, the availability of quantitative information concerning the scenic resource is not sufficient for many management purposes. The information must also be presented in forms useful for particular applications (Zube, 1973). One format for presenting scenic evaluations of forest areas is the scenic beauty map. When combined or overlaid with maps of soil type, elevation, and vegetation characteristics, the scenic resource can more easily be integrated with other resources in multiple-use decision-making (Linton, 1968; Murray and Niemann, 1975). The SBE method has been used to develop such a map for a ponderosa pine forest in northern Arizona (Daniel, et al., 1977).

Another aspect to be considered in evaluating the usefulness of scenic quality information is the compatibility between the esthetic information and other visual analyses currently in use. Because the landscapes most often seen by the public, like those along roadways, are especially sensitive to treatment (Litton, 1974), the combination of esthetic data and visibility data could

be quite useful to the forest manager. For example, a road placement problem could be explored by experimenting on esthetic and visual-access data bases, identifying the scenic quality of the areas visible from different potential road locations, as well as the esthetic impacts of various alternative road placements on views from other vantage points.

Further, the forest manager needs to know not only the current scenic value of areas in his jurisdiction, but also the likely effects of his actions on the future quality of the landscape. Using the SBE method to obtain scenic beauty values, coupled with Forest Service physical inventory data, linear regression models have been developed which predict scenic beauty values based on such features as the density and distribution of trees and amounts of vegetative ground cover and downed wood (Arthur, 1977). When the relationships between physical features of the forest and scenic quality are identified, the scenic effects of various proposed management actions can be predicted and evaluated before any treatment is applied.

The research reported here constitutes an operational test of the SBE method as a means of providing useful information to forest managers. The work involved the development of a scenic beauty map for a mixed-coniferous forest area in northern Arizona. In addition, consideration was given to the relationship between such a map and seen-area mapping tools already in use. Finally, a model for predicting scenic quality was developed, through the identification of forest features which enhance or detract from the landscape.

Specifically, the objectives of this study were

1) to construct a scenic beauty contour map of the Thomas Creek Experimental Watersheds and to determine general guidelines for the construction of such maps (e.g., the number of photosample points needed per landscape area and the number of photos needed per sample point);

2) from a landscape feature analysis for Thomas Creek, to develop scenic beauty response models, and using these models, to predict the scenic effects of the Thomas Creek Management Plan, and

3) to determine the feasibility of using such maps in conjunction with Visual Management System procedures and seen-area mapping techniques.

Each of these objectives is considered under separate headings below.

OBJECTIVE 1: CONSTRUCTION OF THE SCENIC BEAUTY MAP

The construction of the scenic beauty map and the development of guidelines for making such maps proceeded in three stages. The first stage involved the development of a map based on one of the available sets of data for Thomas Creek. The second step included verification of the map, using additional data bases and other verification procedures developed in an earlier scenic beauty mapping project (see Daniel, et al., 1977). The third stage concerned the description of general guidelines for making such maps, based on the experience of the first two stages.

Developing the Scenic Beauty Map

The study site

The Thomas Creek Watersheds, North (TCN) and South (TCS), are located in the Apache-Sitgreaves National Forest, Arizona. The watersheds consist of two largely parallel ravines lying in an east-west orientation and covering about 1100 acres. Across the watersheds the elevation ranges from about 8300' to 9200'. The forest is classified as mixed-coniferous, with ponderosa pine, Douglas fir, white fir, and quaking aspen the predominant tree forms. The topography is generally quite steep, with one-fourth of the slopes having gradients of 35% or more.

The area had been permanently staked according to a regular grid pattern (see Figure 1), with 119 stakes in TCN and 128 in TCS. These stakes were used to identify sample point locations

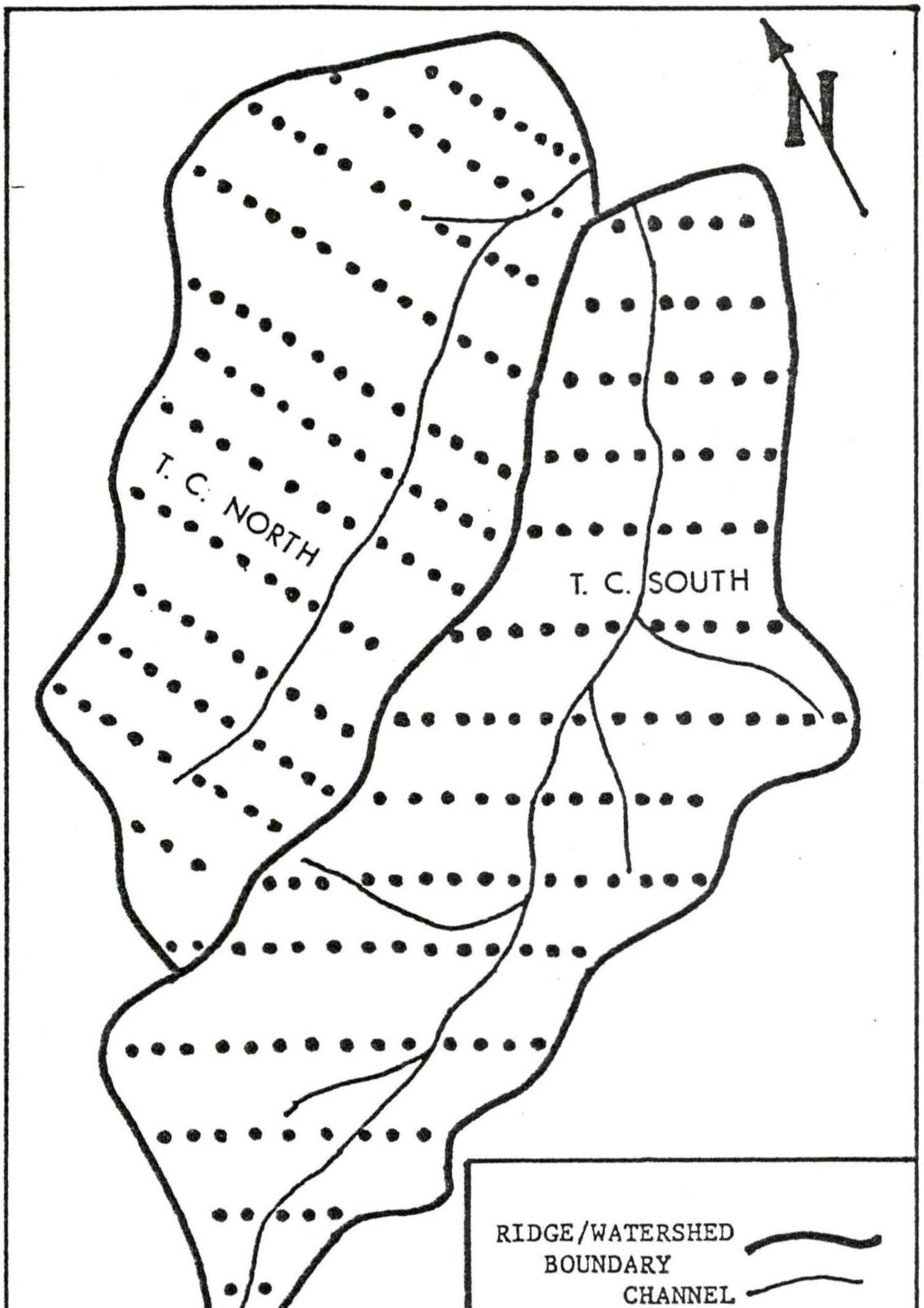

Figure 1. Thomas Creek Watersheds: Location of sample points, channels, and ridges/watershed boundaries.

for the scenic beauty analysis. The stakes ensured that repeated photosamples over a period of years could be taken from the same readily-located positions and the known ground locations of the stakes facilitated the mapping procedure. The sample density was .22 points/acre, or 1 point for every 4.5 acres.

Photosampling procedure

The 1975 photosample consisted of 988 color slides, four taken at each of the 247 points in the grid. To prevent photographer bias, the first photograph at each point was taken at a random orientation by selecting a compass heading from a table of random numbers between 0 and 360. The subsequent photographs were then taken at the random bearing plus 90°, 180°, and 270°. Members of the photography crew also independently estimated the distance of view along the line of sight for each sampled heading. Because of the density of vegetation in Thomas Creek, most views were of rather short distances, less than 200'. However, some slides taken from high points in Thomas Creek included views of other ridges several miles away.

Obtaining Scenic Beauty Estimates (SBEs)

Because the 988 slides in the 1975 sample were far too numerous for one observer panel to evaluate comfortably, several groups were required. From the entire set of slides, 25 were selected at random to be shown in common to all groups. These 25 slides provided a basis for comparison and standardization of the groups later on. The remaining 963 slides were divided at random into 10 sets of approximately 100 slides each. Thirty-seven

previously-judged slides were added to the slide set shown to the last group, to provide a total of 100 slides in each set.

The 100 slides in a set were combined with the 25 common slides and inserted in random order into slide trays. The slides were presented to an observer panel by projection from a Kodak Carousel projector onto a 2m. by 2m. daylight screen. Each slide was exposed for an eight-second interval. The observers were instructed to rate the scenic quality of the landscape scene represented by each slide on the 10-point Scenic Beauty Scale (Daniel and Boster, 1976), and to record their judgments in the numbered blanks on their response sheets. To facilitate accurate recording, a small numeral was projected beside each landscape slide, corresponding to the numbers on the response blanks. This procedure was repeated nine more times, with a different observer panel each time, so that all the slides taken in the 1975 sample were presented at least once. The observer panels were comprised of student volunteers at the University of Arizona, and ranged in size from 17 to 32 individuals, with a mean group size of 23.

The ratings were analyzed by the SBE program (Daniel and Boster, 1976), which provided the relative-standardized SBE values for each slide. The arbitrary origin of the SBE scale was selected to be the mean value assigned to the common set of 25 slides, which were rated by all observer panels.

To verify the equivalence of the ten groups used to evaluate the 1975 photosample, the SBEs derived from the 25 common slides for each group were examined. Because these slides provided the origin for the SBE scale from each group, all groups would by

definition show a mean SBE of 0 for the 25 common slides. On the other hand, the standard deviations of the SBEs for these 25 slides is free to vary from group to group, but must be similar if the SBEs from one group are to be comparable to the other groups. In fact, the standard deviations of SBEs for the 25 common slides in each group were quite similar, ranging from 36.4 to 53.8 with a mean of 42.4. Another check on the equivalence of the different observer panels was performed by correlating the common slide SBEs between each pair of groups. The product-moment correlations ranged from .71 to .89, with a mean of .82. These values satisfactorily established the equivalence of the ten groups in evaluating the scenic quality of slides in the 1975 photosample.

Computer generation of the scenic beauty map

The computer-mapping program used to generate the scenic beauty maps discussed in this report is the SYMAP program (Dudnick, 1971). The program requires as input data an outline of the region to be mapped and the location of the ground points for which values of the mapped variable have been determined. These locations are identified on an x-y coordinate system. The mapping procedure also requires the ascertainment of a single value of the quality being mapped for each identified ground location. The four slides taken at each point in the Thomas Creek grid provided four SBEs, so a single value was derived by taking the average of the four SBEs from a point. The SYMAP program uses a standard topographic interpolation algorithm to assign values to areas lying between the assessed points.

The 1975 scenic beauty map of Thomas Creek produced by SYMAP is shown in Figure 2, with the locations of channels and watershed boundaries sketched in. For clarity the range of SBE values was divided into four equal sections with each section represented by a different level of shading on the map. The degree of shading corresponds to the magnitude of the SBEs for each area, with the most attractive areas (those with highest SBEs) shown in the darkest shade. Inspection of the map shows that the areas with highest scenic value are generally found near the ridgelines, and the least attractive areas are usually found near the channels and in zones at the higher, western end of the watersheds.

Testing the Scenic Beauty Map

Four tests of the 1975 scenic beauty map were made. The first test was an assessment of the adequacy of a four-slide sample from each point, as opposed to samples of one to eight slides per point. The second test explored the adequacy of the sample point density. The third analysis checked the validity of interpolating scenic beauty between sample locations. The fourth procedure tested the reliability of the map, by comparing a 1976 photosample of Thomas Creek with the 1975 scenic beauty data. The testing procedure also provided additional information upon which to base guidelines for the development of maps of scenic quality in forest areas. The use of the mean SBE per point as an index of scenic values around that point was not tested, as earlier research on the esthetic perception of forest roads had shown that public judgments of the scenic quality of a series of

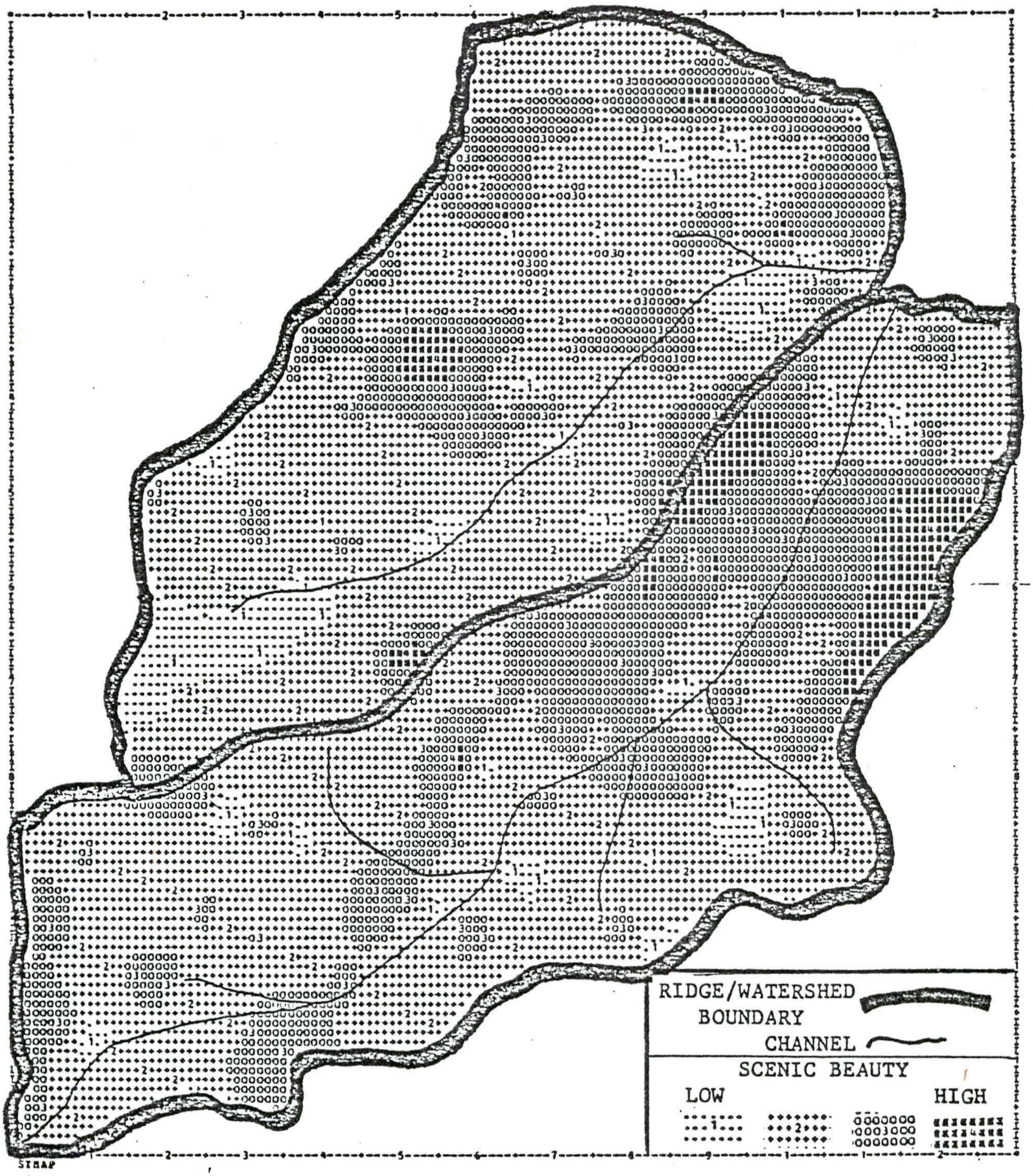

Figure 2. Scenic Beauty Map of Thomas Creek Watersheds.

slides along a roadway, rated as a unit, are well predicted by the average of judgments given separately to each slide in the series (Schroeder, 1976).*

Adequacy of a four-slide sample

The four slides taken at each point encompassed 90° or one-fourth of the 360° panorama around the points. Would one or two slides (45°) have been sufficient to represent the view, or are eight slides necessary to produce reliable scenic quality estimates? The terrain of the Thomas Creek watersheds is quite steep, especially on the eastern half of the area. Four photographs at 90 intervals would be likely to include one shot of the rising ground immediately up the slope from the camera, another across the ravine to the opposing side of the channel, and two shots up and down the ravine parallel to the channel. The shots facing up a slope show much more of the ground and trunks of trees than the shots facing down a slope, which show more of the tree canopy. Such diversity of views would be expected to result in diverse scenic quality estimates for the same location. The question then is how many slides are required to obtain a reliable index of the "central tendency" of scenic quality around a point.

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*Previous work with the SBE method (Daniel and Boster, 1976) has confirmed that evaluations of scenic quality for an area are similar when made by observers on the site and by observers rating color slides of the area.

The reliability of using one slide per point was assessed using the 1975 data. If one slide (22.5^{o}) is an adequate representation of the view from a point, one would expect a high correlation between the value assigned any one slide and the mean value assigned the remaining three slides at each point. Thirty such correlations were calculated, each based on different independent random selections of one of the SBEs at a point, paired with the mean of the remaining three SBEs, for the 247 sample points. These correlations were all low but statistically significant, ranging from .14 to .27 with a mean of .19. These values indicate that the lower limit on reliability of scenic data, based on one slide per point in rather rugged terrain, is low indeed. By comparison, the same procedure carried out on the scenic beauty data for Woods Canyon Watershed, Coconino National Forest, a relatively flat, ponderosa pine forest area, resulted in a mean correlation of .49 (Daniel, et al., 1977).

Two slides per point produced a slight improvement in representing the view from a point. Thirty split-half correlations were computed, using the means for pairs of the SBEs at each point, based on different random divisions of the four SBEs from each point into two pairs. These split-half correlations ranged from .18 to .31, with a mean of .25. For Woods Canyon, this repeated split-half procedure produced a mean correlation of .55.

To explore further the adequacy of a four-slide sample, a 1976 photosample was used. In this sample, eight slides were taken at each of 41 of the stakes in Thomas Creek, 19 in TCS and

22 in TCN. (A complete panorama would be encompassed by 16 slides.) As in the 1975 sample, the first slide at each point was oriented along a random compass heading. Subsequent slides were taken at 45° intervals from the original bearing.

Fifteen of the points were randomly selected for analysis and the 120 slides from these points were presented in random order for evaluation by a group of 30 student volunteers, following the procedure described earlier.

The SBEs for the slides were split into two sets of four slides around each point, using slides at 90° intervals within the sets (e.g., 0°-90°-180°-270° and 45°-135°-225°-315°). The correlation between the means for these sets was .76, a large improvement over the split-half correlations based on the four-slide 1975 sample.

The mean SBE for all eight slides at a point was then calculated and correlated with the four-slide mean based on the 1975 sample. This correlation was .55, indicating that a four-slide sample gives a fair approximation of the value one could obtain using a larger number of slides to represent a point.

Adequacy of sample point density

The 247 sample points in Thomas Creek were distributed across the watersheds at a density of about .22 samples per acre, or 4.45 acres per sample point. No tests of a greater density are possible with the data available. However, it is possible to

test the effectiveness of a less concentrated sample by generating maps based on subsamples of the 1975 SBE data.

A sample density of .11 points/acre would result if half of the 1975 sample points were deleted. Two such maps based on the 1975 SBE data for odd- and even-numbered stakes, respectively, are shown in Figures 3a and b. These map are quite comparable to the map in Figure 2, which is based on all sample points. However, a map of greater resolution, say, one with 10 levels, would show considerable degradation with the half-sample. The correlation between the even- and odd-numbered stake maps was obtained by correlating the values for each cell in the computer maps. The value obtained was .21. The respective correlations between the odd- and even-numbered stake maps and the complete map were .73 and .68.

The relationship between map quality and sample point density was explored systematically by comparing the 1975 scenic beauty map with maps based on randomly-selected subsamples of the 247 points. Nine levels of partial samples, ranging from 90% to 10% of the available data, were used to generate maps which were then correlated with the complete or 100% map. Ten maps at each sample density were developed, each based on a different random deletion of the appropriate percentage of data. The coefficient of determination (r^2), an index of information content, was calculated for each map. The results of this analysis are shown in Figure 4. In the same figure are shown the coefficients of determination for the 50% maps based on even- and odd-numbered points. The stratification of the subsample that resulted when

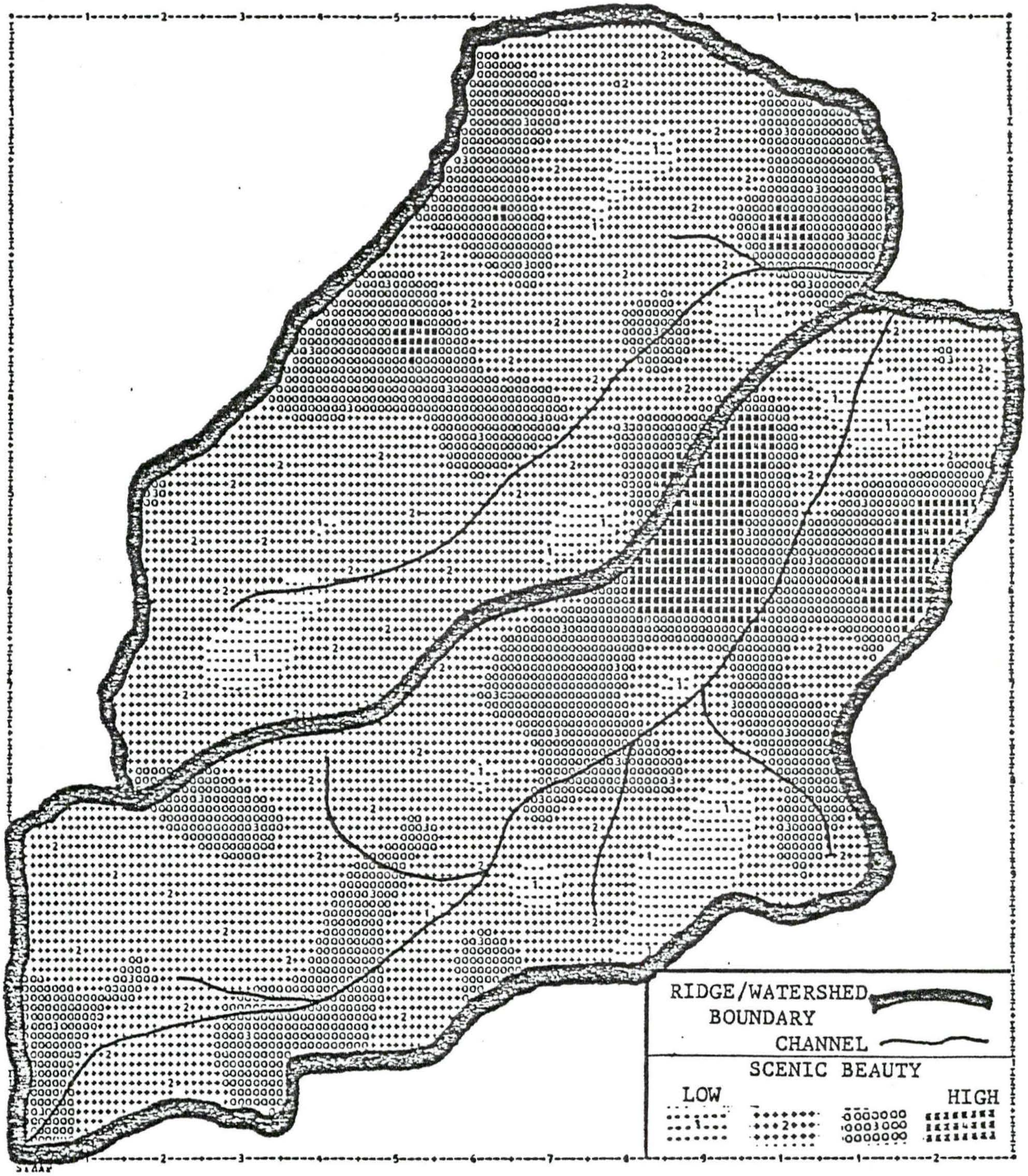

Figure 3a. Scenic Beauty Map based on odd-numbered sample points only.

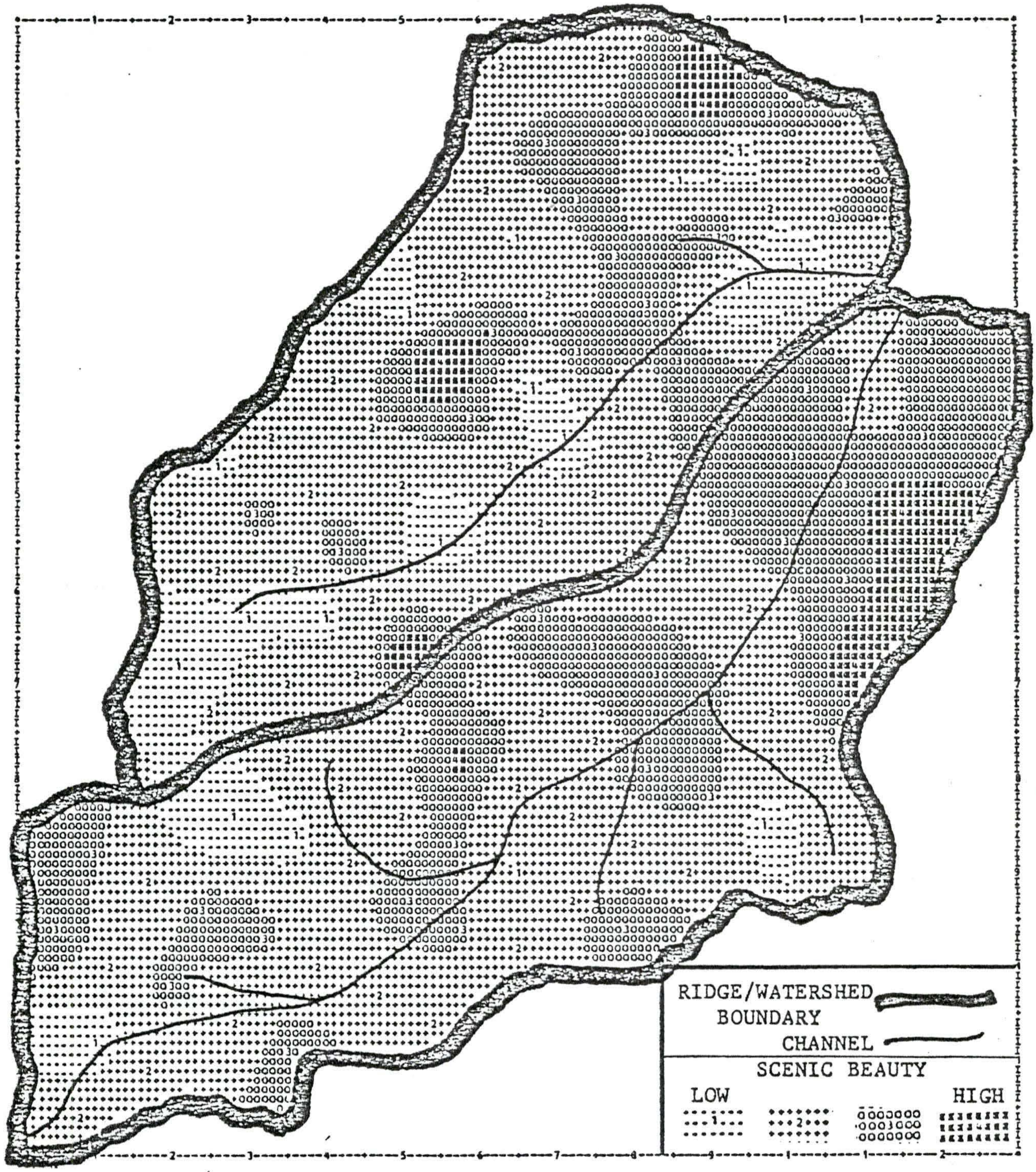

Figure 3b. Scenic Beauty Map based on even-numbered sample points only.

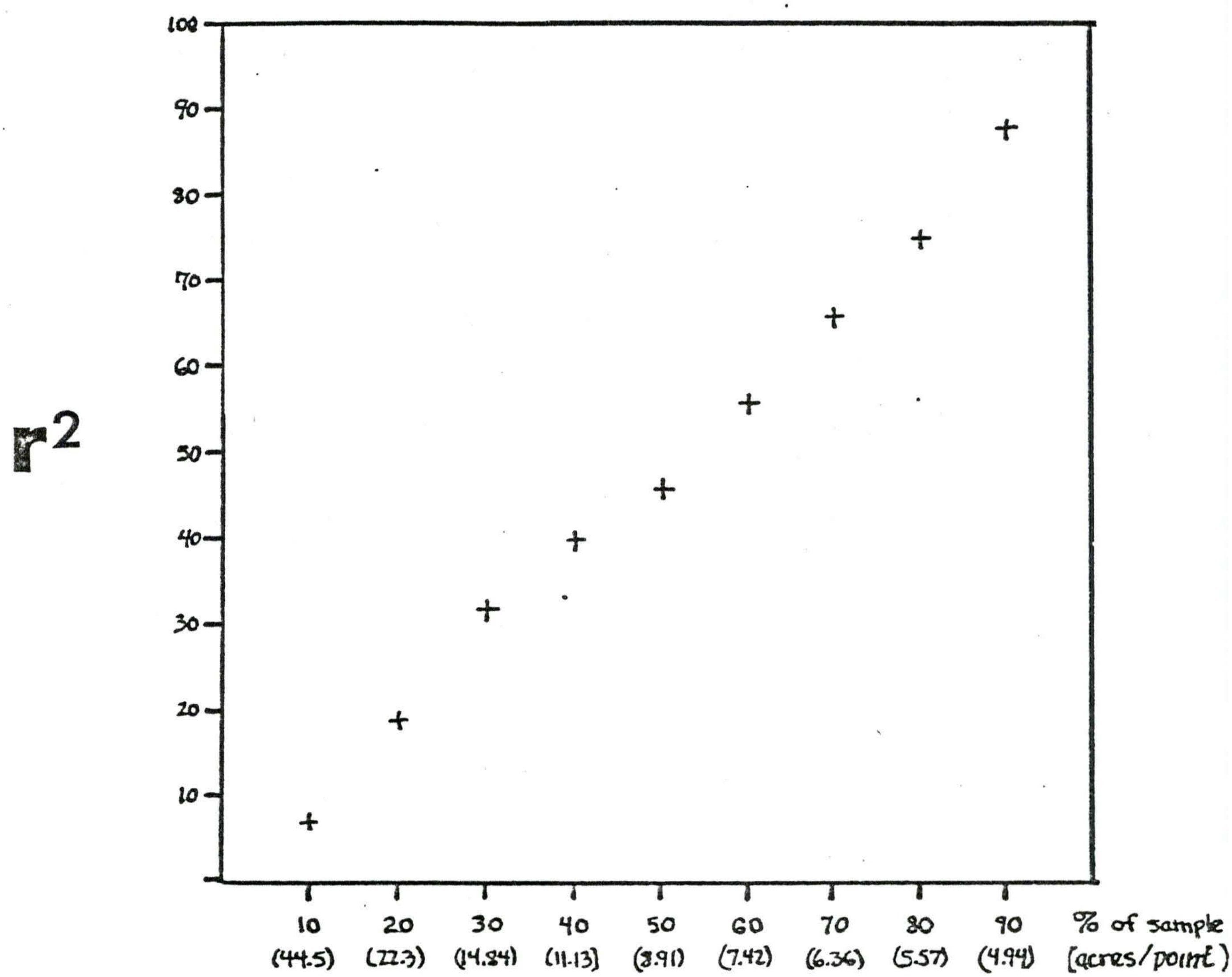

Figure 4. Relationship between sample point density and coefficient of determination (r^2) with map based on 100% of sample.

every second point was removed increased the accuracy of the map slightly over a random deletion of the same number of points.

It can be seen in Figure 4 that increases in sample density over the range studied here add linearly to the resolution of the map. Theoretically, one would expect this function to reach an asymptote so that increases beyond a certain density would add increasingly less information to the map. The maximum sample density obtained for Thomas Creek, .22 points/acre, is not past this point of diminishing returns. Therefore, one would expect that at least another 10% or 20% increase in sample density would result in an improvement equal to that given by the 1975, 100% map over the 90% and 80% maps generated for this analysis.

The resolution of the map is directly related to sample point density. It therefore follows that the adequacy of a particular sample density depends upon the use to be made of the map. The 50% maps in Figure 3 show that for a rather imprecise analysis, a sample point density of about .10 points/acre would be sufficient to identify large zones of high scenic quality in rugged terrain like that of Thomas Creek. As the sample is further degraded, the maps lose detail and with only 30% of the sample, the main features, like the difference between eastern and western halves of the watersheds, are lost. By comparison, the same values of the coefficients of determination were obtained in Woods Canyon at a sample point density of .023 points/acre.

Validity of interpolation

The computer-generated map of Thomas Creek has 9000 cells, roughly 36 for each cell containing a sample point from the 1975 photosample. The values for cells in which photosample points fall are determined by the SBE values for those points. The values for intervening cells are determined by a distance-weighted interpolation formula. The validity of the interpolation algorithm can be assessed by comparing interpolated scenic beauty values from sample points with their respective obtained SBE values.

The correlations of interpolated and obtained values for particular points are much more sensitive to sample degradations than are correlations for complete maps. When all 9000 cells of two maps are correlated, as in the test of sample point density, the redundancy of cells around the retained sample points serves to increase the correlation. The correlations of interpolated and obtained SBE values for particular deleted points are tests of the power of the remaining data to predict detail in the map. As in mapping elevation, interpolation can be expected to be effective given some minimally representative sample density and to continue to improve as sample density increases.

Testing of the interpolation algorithm was based on studies of random degradations of the 1975 data base. Maps based on 90% of the sample points were generated for this analysis. The intepolated values of cells whose SBE values had been deleted from the data were located in a SYMAP output table. These values were correlated with the originally obtained SBEs for each of the

deleted sample points. Twenty correlations were calculated, one from each of the 90% sample maps.

Any relationship between interpolated and obtained SBE values for points is almost undetectable when 10% of the points have been deleted. The average correlation for the 90% maps is .18 (r^2=.03). However, the maps based on random 90% samples are quite similar to the 100% sample maps in presenting the general distribution of scenic quality across Thomas Creek.

The validity of interpolated values in the 100% sample map is expected to be greater, although a denser sample than that taken in 1975 is required to test this. The relatively low correlation of the 95% sample indicates that the 1975 map may not represent the areas between sample points adequately. In Thomas Creek scenic quality may vary across small plots (1-3 acres) so sharply that the .22 points/acre sample density is insufficient to represent the landscape. By contrast, for Woods Canyon a sample point density of .023 points/acre provided interpolations which correlated at .41 with obtained scenic beauty values.

Reliability of the map across time

Evaluations of photographic samples from the two years, 1975 and 1976, were used to test the reliability of the Thomas Creek scenic beauty data across time. The correlation between the four-slide sample of 1975 and the eight-slide sample of 1976, for the 15 sample points which had been evaluated, was .55. This value satisfactorily establishes the reliability of the scenic beauty data for Thomas Creek.

Results of tests of the Thomas Creek scenic beauty map

Tests of the representativeness of views at a point showed that the mean of independent SBEs, each representing a single viewpoint from a sample location, was an accurate index of the quality of views from that point, as earlier work had indicated (Daniel and Boster, 1976; Schroeder, 1976). In addition, a four-slide sample at a point was found to be about as good at representing the areas as an 8-slide sample, while a 2-slide sample was clearly insufficient. Finally, the scenic beauty data at sample point locations were found to be reliable across a one-year time period (1975-1976).

The results of tests of the sample point density are not so satisfatory. The sample point density directly affects the resolution of the map. Given some minimal number of samples, optimum sample density then depends on the use to be made of the map. In Thomas Creek, sample densities as low as .11 points/acre reproduced a substantial amount of the information obtained from the full sample map based on a density of .22 points/acre. The main shortcoming of the map revealed by these tests concerned the validity of interpolating scenic beauty data across terrain. The interpolation studies showed that SBE values for points surrounding a given sample point were somewhat unsatisfactory predictors of scenic quality at that point, a result which calls into question the validity of interpolating scenic values in Thomas Creek. A denser sampling of views from the area might resolve this issue. However, the sampling density was probably as thorough as is practicable for the assessment of a 1000-acre

area. A steep and thickly-vegetated area like Thomas Creek may simply not be amenable to interpolation, and therefore be unsuitable for mapping. By contrast, in Woods Canyon a sample point density of .023 performed very well in representing the landscape.

Guidelines for Construction of Scenic Beauty Maps

The accuracy of a scenic beauty map of a landscape will be directly related to the thoroughness of the representation of views sampled from that landscape for evaluation, in terms of both the number and distribution of sample points and the number of slides from each point. In general, a specific choice of sample point density will be optimal depending upon both the intended use of the map and the variability of views within the mapped area. A specific choice of the number of views to sample from each point will be optimal depending upon the variablity of views around that point.

The following suggestions are based upon the experience gained in developing the Thomas Creek scenic beauty map, and in the earlier work with a map of Woods Canyon.

1. The number of landscape samples to take at a specific ground location depends on the variability in views at that location. In the steep terrain and heterogenous vegetation characteristic of Thomas Creek, four slides at a sample point, representing one-fourth of the view around each point, gave an adequate representation for each location. In contrast, in the relatively flat ponderosa pine forest at Woods Canyon, one slide

at a point proved to be about as good a representation as the four slides per point were for Thomas Creek.

However, because film costs are far less than the transportation and labor costs involved in collecting a photosample, the suggested strategy is to collect as extensive a photosample as possible, at least four slides per point. Then, if it is discovered that one or two slides are insufficient to represent a point, a more complete representation will be available for evaluation.

2. The number of samples to take at a sample point need not be constant over the region to be mapped. Consider Figure 5, a map of the standard deviations in SBEs for the four slides at each stake. It can be seen that the greatest variability in views around a point occurs near the channels, and the lowest on the less steep western half of the area. Points located along edges--between forest and meadow, and north- and south-facing slopes--need more samples than points midway up a low gradient ridge, or lying in a relatively flat forest area like Woods Canyon.

3. The optimal sample density for an area will be a function of the variability of views in the area. For Thomas Creek, the sample point density was about .23 points/acre, or one for every 4.4 acres. This map proved to have less effectiveness in representing intervening areas than the Woods Canyon map, based on a sample density of .023 points/acre, or one sample point for every 43 acres. The differences in topography and vegetation characteristics between these two landscapes have been

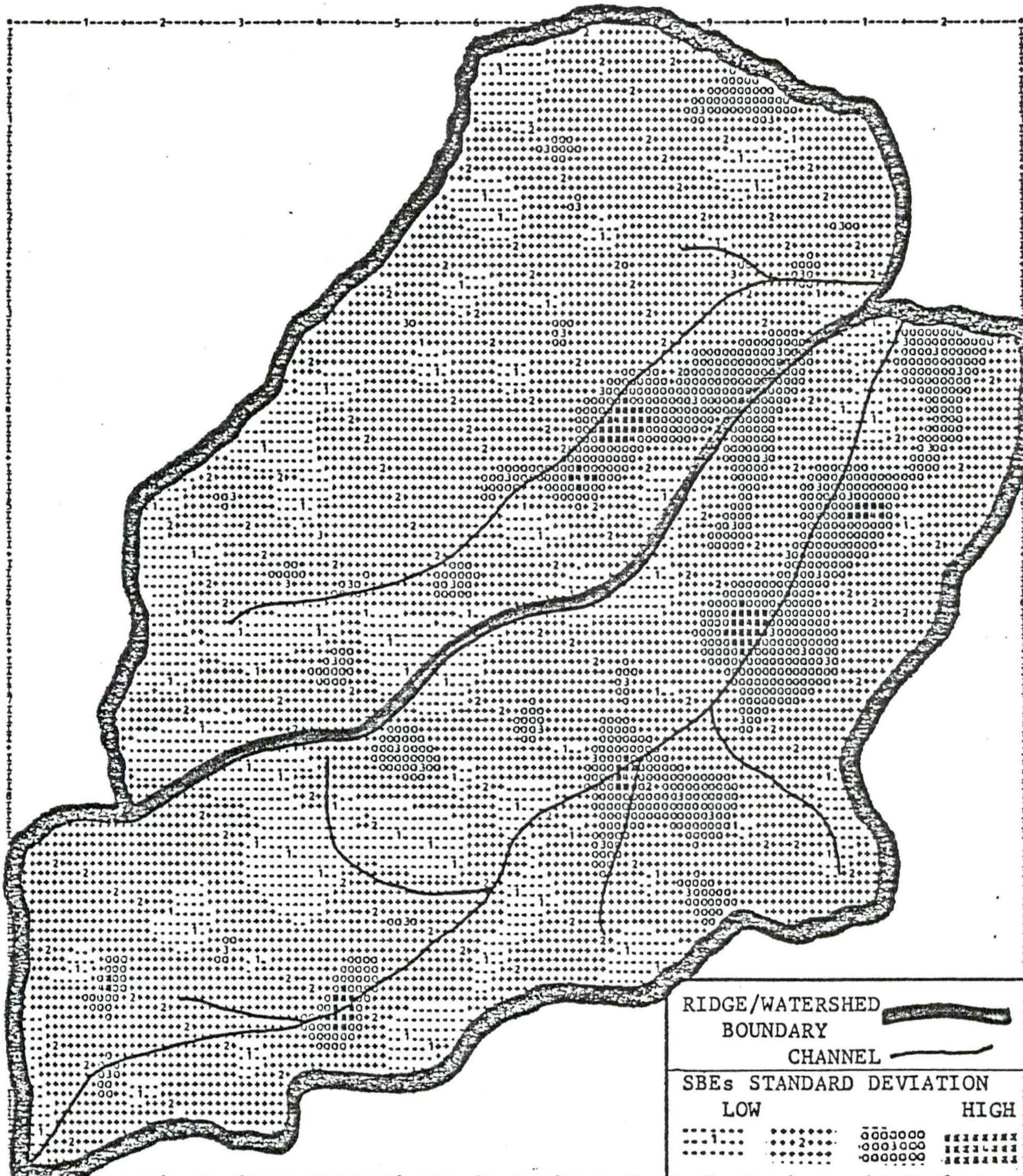

Figure 5. Map of standard deviation of SBE values at each sample point.

noted. With experience, one could use topographic data and/or aerial photographs to decide the basic variability in terrain and plan an optimal distribution of point-samples accordingly.

4. The optimal sample point density for an area need not be constant across the area. With aerial photography, for instance, one could also identify parts of the area to be mapped which could be represented by fewer points, and perhaps other areas--along channels, near meadows, or near stand boundaries--which would need a denser sample.

5. The optimal sample density is also a function of the intended use of the map. A scenic beauty map of an entire National Forest to identify major areas of greater scenic quality would not require the same sample density as was used in Thomas Creek. However, for planning a 45-minute nature/photography trail within a region of high scenic quality, resampling of that region using a very dense sample point distribution would provide a map suitable for planning at that level of detail.

OBJECTIVE 2: DEVELOPMENT OF PREDICTIVE MODELS OF SCENIC BEAUTY AND EVALUATION OF THOMAS CREEK MANAGEMENT PLAN

The SBE method has been used successfully in developing predictive models of scenic quality using forest physical features in ponderosa pine forest areas, including Woods Canyon (Arthur, 1977; Daniel, et al., 1977). For the Thomas Creek predictive analyses, the variables identified in the earlier work were used along with some additional ones to predict SBE values. These variables are listed in Figure 6. The variables used previously included the distribution of trees in the landscape, and the densities of trees of three size classes, as well as the amount and distribution of downed wood and the amount of vegetative ground cover. The new variables are greenness of vegetation, and view range. Greenness of vegetation is an index of the amount of green leafy matter shown in each slide. Dead trees, views of many bare trunks, or brown or sparse ground cover reduced the rating on this variable. View range was the photograhic crew's estimate of the distance that could be seen into the forest along the orientation of each slide.

The predictive models were based on ratings of individual slides for each of the features listed in Figure 6. Thirty-eight stakes were selected, representing a stratified sample of views across the watershed. The four slides from each stake were independently rated for each of the physical features, using a five-level scale. The view range values were taken from the

FEATURE	RATING SCALE INTERPRETATION -1-	-5-	SIMPLE r WITH SBE[a]	B-COEFFICIENTS USING MANAGEABLE FEATURES[b]	USING ALL FEATURES[c]
Downed wood amount	small amount	large amount	-.62[d]	-.58[d]	-.52[d]
Greenness of vegetation	low (see text)	high	.58[d]		.42[d]
View range	estimated in feet		.23[d]		.16[d]
Tree density 4-6" dbh	low	high	.26[d]	.13	.05
8-12" dbh	low	high	-.24[d]	-.09	.04
14" dbh	low	high	.10	.15[d]	.04
Tree distribution	even	clumped	.10		.01
Vegetative ground cover	small amount	large amount	.09		-.01
Downed wood distribution	scattered	piled	-.04		.10
			Multiple R	.65	.78
			Multiple R^2	.43	.61

[a]Based on 152 cases.
[b]Based on 143 cases.
[c]Based on 143 cases.
[d]$p < .05$.

Figure 6. Regression analyses: Predicting SBEs from landscape characteristics

distance estimates made during the photosample collection. The interpretations of the rating scales for each feature are shown in Figure 6.

The simple correlations between the rated features and SBEs for the slides are also shown in Figure 6. It can be seen that downed wood correlates strongly and negatively with scenic quality, a relationship which has been noted before (Arthur, 1977). Another strong correlation is found for the rating of greenness of vegetation. Vegetative ground cover alone was not a strong contributor to the scenic quality of Thomas Creek, largely because the range of this variable was severely restricted at the time the photosample was collected.

The correlations between tree density variables and scenic quality are much lower than the correlations found for these variables in Woods Canyon. This is probably due to the restricted range of these variables in the case of Thomas Creek. In TCS less than 1% of the 562 acres are meadow, while the large meadows in Woods Canyon constitute one of its most outstanding features.

One regression model was generated using only the tree density, tree distribution, and amount of downed wood variables to predict SBE values. The model accounted for 43% of the variance (multiple-$\underline{R}$ = .65), with downed wood amount alone responsible for 39%. The tree density variables together accounted for only 4% of the variance, and only the density of large trees ($\leq$14" dbh) was statistically reliable. The

beta-coefficients for the variables included in this regression are shown in Figure 6.

A second regression, using all of the variables, accounted for 61% of the variance (multiple-R = .78), with downed wood amount again accounting for 39%. The major contributors to variance after downed wood included the index of greenness of vegetation (13%) and the view range (2%). The beta coefficients for variables in the second regression model are also shown in Figure 6.

The results of this regression analysis are not suitable for the development of predictive models of scenic beauty based on manageable forest features. The downed wood variable is the only manageable forest characteristic which contributes strongly to scenic quality. The obtained relationships between tree density variables and SBE values here are negligible.

The scenic effects of alternative treatments proposed for Thomas Creek cannot be evaluated quantitatively for lack of an adequate model. However, some suggestions can be made based on the variables which were found to be related to scenic quality in the analysis reported above.

Greenness of vegetation and view range variables showed a positive relationship to landscape quality and are also related to tree density. Treatment procedures which lead to openings in the forest would probably enhance the landscape in Thomas Creek. For one thing, such open areas would increase view range. In particular, thinning the tops of ridges would increase visibility to distant ridgelines. It should be noted that the few panoramas

or long-range views in the 1975 photosample received the highest ratings in the SBE analysis. Further support for this suggestion is derived from a study of harvest recovery functions (Wheeler, 1976). Harvesting a dense spruce stand in San Juan National Forest, Colorado, immediately led to higher SBE values, largely because of the opening of panoramic views which had been obscured by dense vegetation.

Thinning or clearcutting in irregular patches could also increase scenic quality by encouraging vegetative ground cover. This feature was not found to be powerful in the regression analysis, largely because most slides of Thomas Creek showed very little of this variable. However, among the highest-rated slides in the 1975 photosample, those which did not include a panorama invariably showed a small clearing carpeted in grass and other plants.

Finally, as the Thomas Creek regressions and several other applications of the SBE method have shown, downed wood has a strong negative effect on scenic beauty. Therefore, any treatment of Thomas Creek should include removal of as much downed wood as possible.

OBJECTIVE 3: RELATIONSHIP BETWEEN THE SCENIC BEAUTY MAP AND OTHER VISUAL MANAGEMENT TOOLS

This objective was approached in two stages, a comparison of a VIEWIT "seen area" analysis to actual visibility as assessed at selected points in Thomas Creek, and a comparison of the Visual Management System analysis of Thomas Creek with the scenic beauty map. The relationship between the different analyses and the potential utility of combinations of these tools is discussed.

The VIEWIT analysis

The VIEWIT program (Amidor and Elsner, 1968; Travis, et al., 1975) uses digitized topographic data and standard surveying formulas to predict the visibility of one area from another. For the Thomas Creek analysis, two stakes were selected, #26 and #67 in TCS, the former located near the ridge in the eastern half of the watershed, and the latter near the channel midway between the eastern and western halves of the watershed. The VIEWIT program was executed to identify the terrain within TCS which was not screened by landforms from these two points. The VIEWIT output maps are shown in Figures 7a and b, and indicate that quite a lot of the watersheds should be visible from these points.

However, landform is not the only source of screening in a forest area. In fact, vegetative screening probably has a greater effect on visibility than landform. A photograph taken along the line of sight sketched in Figure 7a and reproduced in Figure 7c illustrates this point. The photographic crew

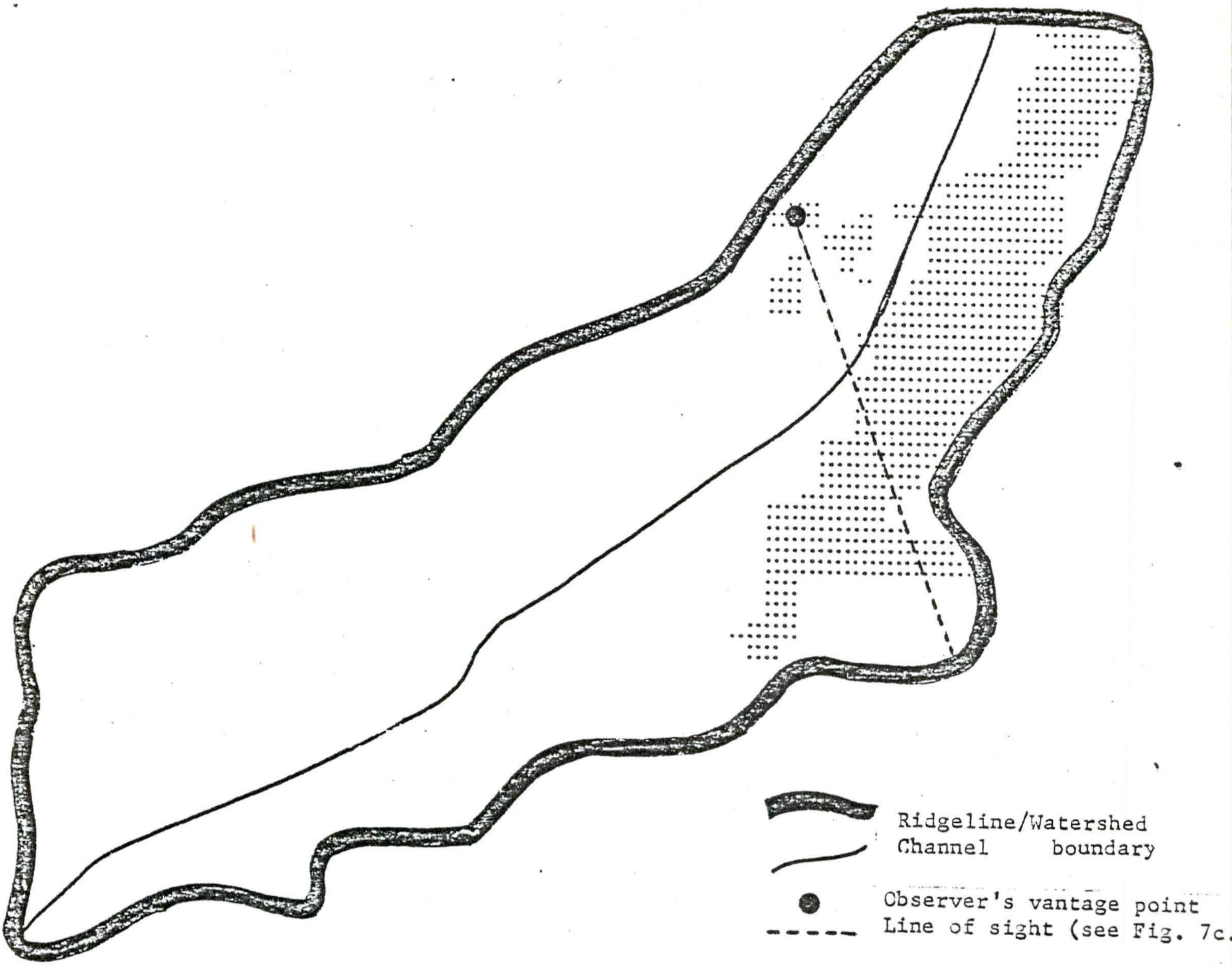

Figure 7a. Map of visible area (shaded) predicted by SYMAP for TCS Stake #26.

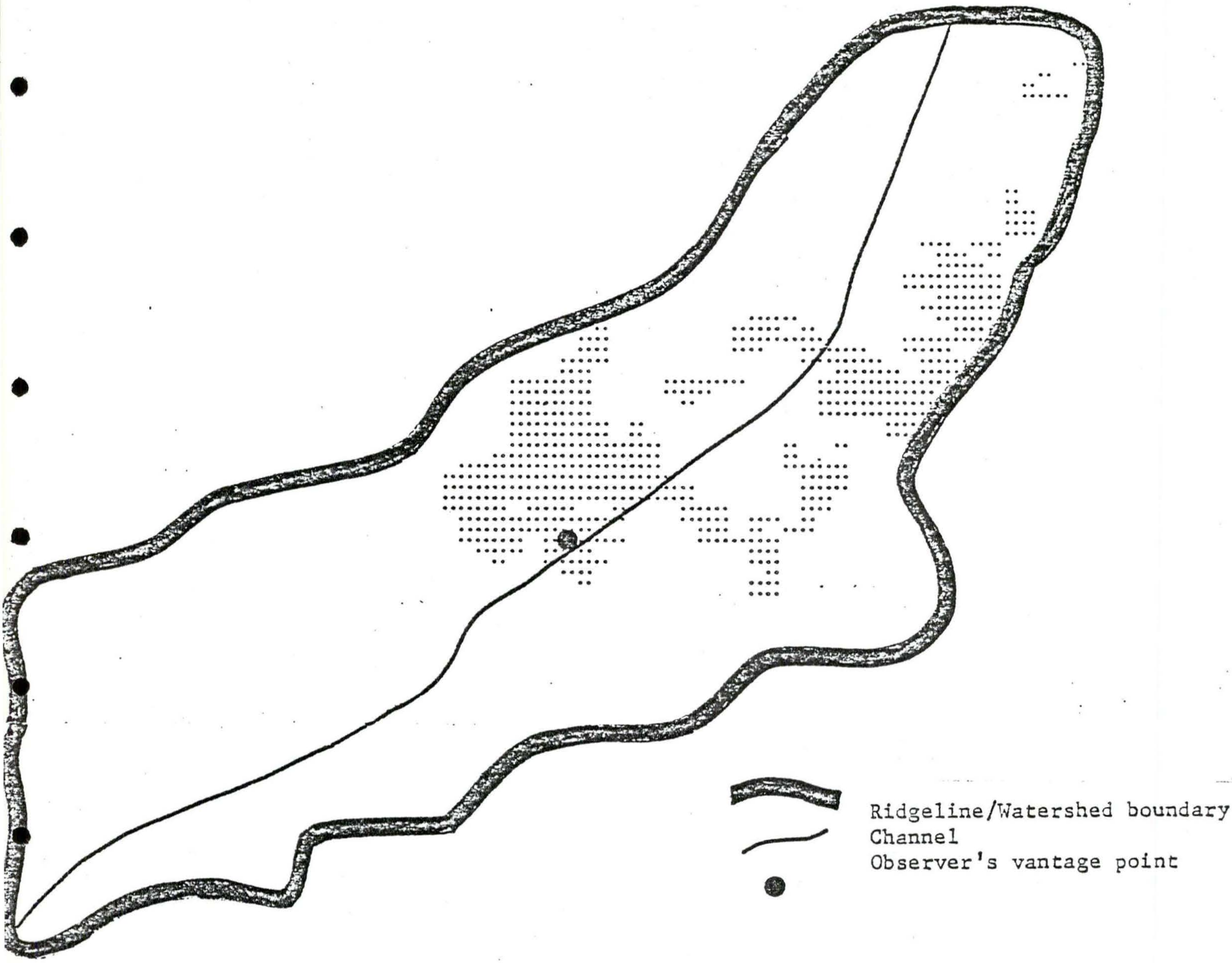

Figure 7b. Map of visible area (shaded) predicted by SYMAP for TCS Stake #67.

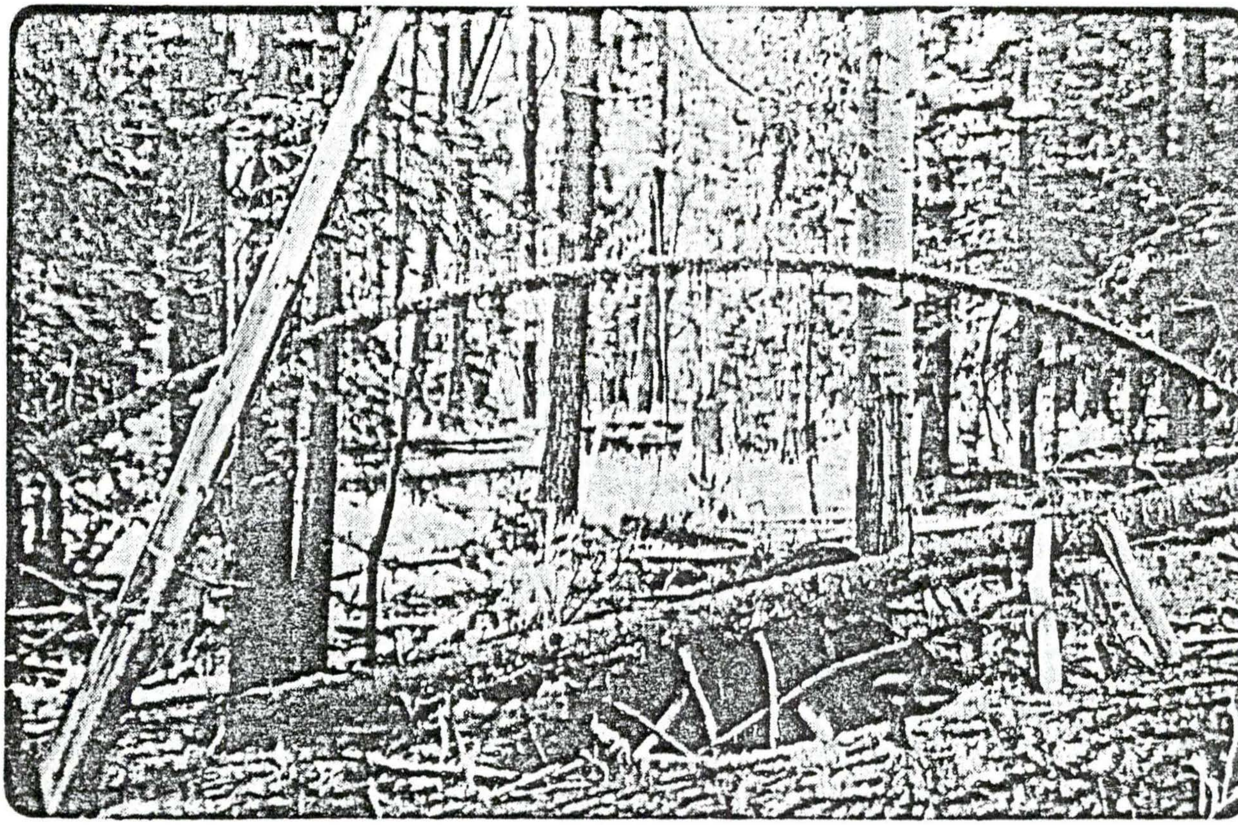

Figure 7c. Reproduction of slide taken at TCS Stake #26 along line of sight sketched in Figure 7a.

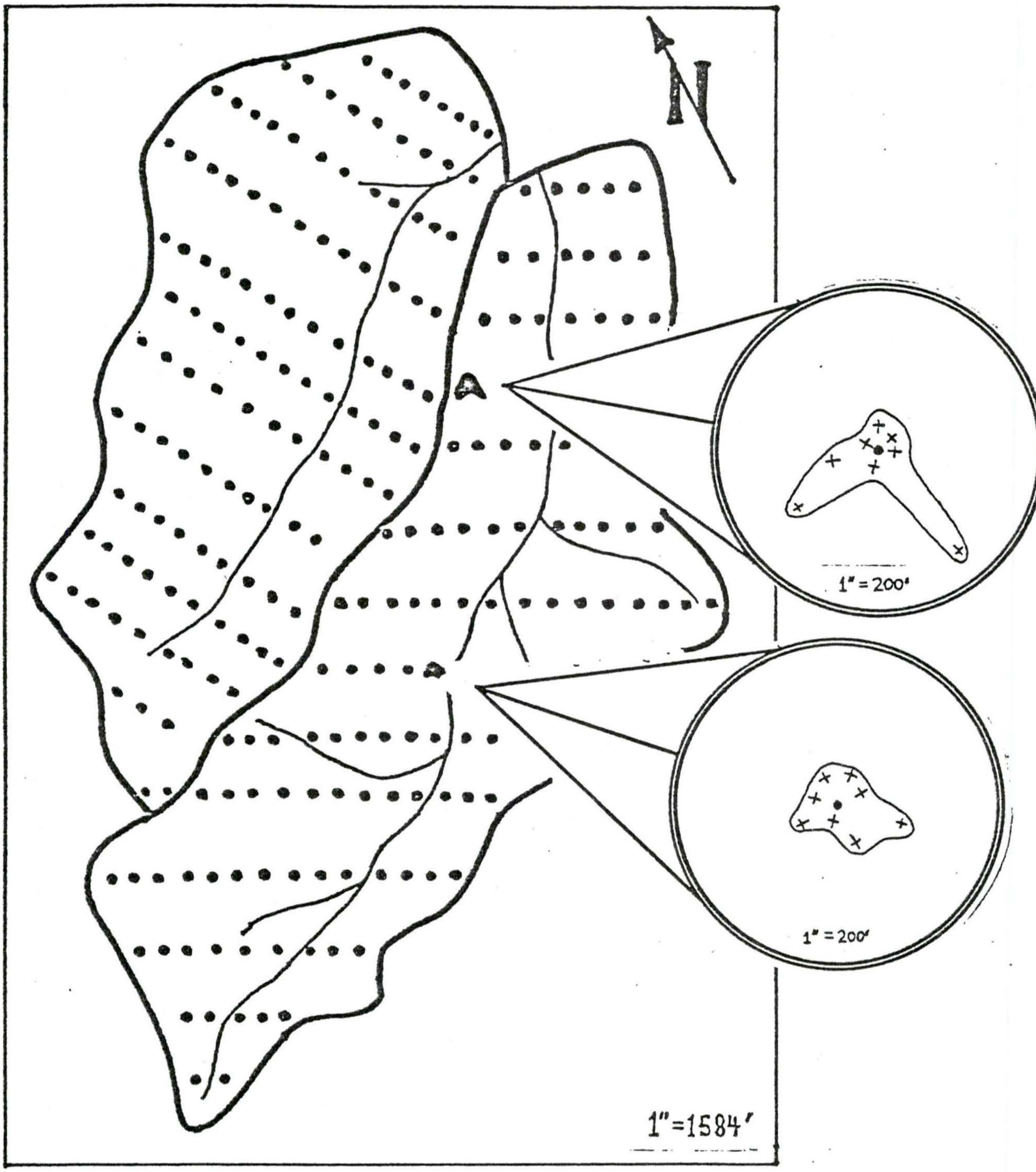

Figure 7d. Field-assessed visibility from stakes 26 and 67 in Thomas Creek South.

collecting the 1975 and 1976 landscape samples for Thomas Creek also estimated the distance they could see into the forest along the line of sight for each slide collected. Figure 7d indicates the field-assessed visibility for the two points analyzed by VIEWIT.

For purposes of locating a fire tower, which will extend above the tree canopy, VIEWIT may be sufficient. For planning concerning the scenic resource, where the viewer will be standing on the ground, vegetative screening must be taken into account. Refinement of the VIEWIT program to allow treatment of surrounding terrain as a screen whose permeability depends on vegetative characteristics is essential if this program is to be used successfully to predict visibility for landscape planning.

The VMS analysis

A VMS evaluation of Thomas Creek was not available. However, based on the experience with VMS in Woods Canyon research, it is likely that VMS would place Thomas Creek in one or two categories of landscape, according to its landform and vegetation characteristics. VMS does not distinguish gradations of scenic quality within the landscape categories, however, while the SBE method can provide such information.

The VMS categorization of landscapes and scenic beauty maps based on the SBE method are complementary. The classification schema of VMS provides sufficient detail for large scale regional planning. The SBE method and maps based on data obtained by this method can provide reliable, precise data on the distribution of scenic quality within the landscape zones defined by VMS. For

instance, where VMS designates an area for "partial retention," the SBE method can provide specific information about procedural changes which would minimize the scenic impact of harvesting procedures, or of routing power lines or roads through a forest area. As indicated before, various resolutions of scenic beauty maps are also obtainable, depending on the use to be made of the map.

CONCLUSIONS

The 1975 scenic beauty data for Thomas Creek have been shown to be reliable and valid representations of the scenic quality to be found at the sample point locations. The scenic beauty map based upon these data probably gives a good picture of the gross details of scenic quality in Thomas Creek, such as the relatively high scenic beauty to be found along the ridges in the lower half of the area. However, the accuracy of interpolating between sample points in the steep and densely-forested terrain of Thomas Creek has not been satisfactorily demonstrated. A sample point distribution denser than .22 points/acre may be required to represent fully this type of area, although the density used in Thomas Creek represents the upper limit on density for practical reasons. A sample distribution one-tenth as dense as that used in Thomas Creek produced good results in the flatter ponderosa pine forest of Woods Canyon.

Procedures for obtaining the data necessary for generating scenic beauty maps were discussed. To be used in constructing maps, the SBE technique needs only the minor modifications of 1) recording actual ground locations for each slide and 2) taking at least two slides at each sample point, depending on the variability in the view around each point. The mapping procedure for rugged areas will be the same as that for other areas, except that the sampling density must be much greater. Even then, the

map cannot be expected to be of the same quality as maps of areas with more uniform topography.

The combination of visibility analyses and scenic beauty data is still desirable. However, for forest areas, visibility analyses must take into account vegetative screening before their successful utilization is assured. The relationship between VMS and the SBE method is one of complementarity. The detailed scenic beauty information produced by the SBE method can contribute to planning for regions falling within the different VMS categories.

Scenic quality of mixed-coniferous forests

The tests of the validity of interpolating scenic beauty data across terrain as rugged as Thomas Creek led to the tentative conclusion that such areas are not suitable targets for mapping. The sample point density required is simply too great to be practical. During the course of this research, other observations were made concerning the role of scenic quality for densely-forested areas that mitigate this conclusion.

It may be that the scenic beauty to be found within a steep, densely-forested area is less important than the scenic quality of such a forest as viewed from outside its bounds. In Woods Canyon, panoramic views are rare. However, the general openness of the ponderosa pine stands and the presence of several large meadows produce a generally greater viewing distance within the area. The observer in Woods Canyon can frequently see far enough to have a "satisfactory view." In Thomas Creek, visibility is

severely restricted by vegetation--the observer can rarely see more than 150' and that through trunks and branches of intervening trees. However, along the ridges in Thomas Creek are to be found a few open vistas extending to distant hillsides. Slides taken at these points received the highest SBE ratings in the Thomas Creek analysis (SBEs in excess of 120).

The effect of visibility "out of" mixed-coniferous forests, or at least being able to see areas outside one's immediate perimeter, is striking. At the same time, forests covering steep terrain may be part of a landscape much more beautiful than any particular view to be found within such a forest. And, dense forests covering steep hillsides are probably viewed by more people from outside, as from a road passing nearby, than from inside. Mapping such an area on the basis of the scenic quality within it overlooks one of its most important contributions toward scenic beauty. In contrast, the gentle topography around Woods Canyon enables the motorist driving through the area to see little beyond the forest skirting the road and any meadows the road passes through. The individual travelling primitive roads through the area sees more of Woods Canyon forests. Mapping such areas produces a good representation of the way they are seen by the public.

The preceding discussion leads to the suggestion that the relationships between panorama and scenic beauty in areas like Thomas Creek should be further explored. Landscape architects have identified panorama or vista as an important variable in the

determination of scenic quality (Litton, 1966; Leopold, 1969.) The SBE method has been applied successfully to esthetic evaluation of some southwestern desert areas which are characterized by panoramic views (Daniel and Anderson, 1976). The method could also be used to evaluate the role of dense forests of the mixed-coniferous type in long-range views, and to assess the effects of harvesting and other treatments on the appearance of such forest areas as seen from the outside. Investigation of the role of dense forest areas within a view may be more fruitful than investigation and mapping of views within such forests.

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